



## Social cognition of climate change in coastal community: A case study in Xiamen City, China

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### ABSTRACT

Climate change has caused a series of social, economic and environmental consequences both at global and regional scales, especially for the urbanized coastal areas in China. Sea level rise and extreme weather threaten human and property safety, as well as sustainable development in China's densely populated coastal areas; all those factors bring new challenges to coastal management. This paper takes a typical coastal city, Xiamen City as a case to study the residents' cognition of climate change, and based on questionnaire survey in coastal communities to explore the strategy development dealing with the climate change under integrated coastal management (ICM) framework. The social cognition survey includes three aspects: knowledge of the climate change, perception of the impact of climate change and response to the climate change. The results showed that the resident's knowledge on climate change and its risk was still at a relatively low level on average. Among effects of climate change, temperature rise can be easily identified by people, while sea level rise is less known by residents. Facing climate change, if residents have plans reactively, we think their attitudes are positive, i.e. evacuation is seen as negative. It is delight that 69.6% residents' attitude to adapt climate change is positive. 42.0% of residents prefer protective measures rather than adjustment measures when facing climate change. Furthermore, we explored the primary factors that influence residents' cognition and selection preference on adapting measures through logistic regression. Our study suggests that public cognition significantly affect public participation on climate change and the community-based planning and management on climate change is urgently in need in the rapidly developing urbanization coastal areas, which will play an important role in integrated coastal management.

### 1. Introduction

In recent years, climate change becomes more serious, which posed a particular risk for coastal areas. The fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) indicates that the low-lying coastal areas in many Asian countries are facing increasing challenges in various degrees and shocks of climate change (Field et al., 2014). Coastal regions, which accommodate 43.3% of population and 57.9% of GDP with 14% land space in China, confront serious challenge of climate hazard (State Oceanic Administration, 2015; Bender et al., 2010; Vermeer and Rahmstorf, 2009). The dangers will be especially serious to these regions with high density of population and rapidly growing economies, while their abilities to cope with climate change are limited (Nicholls and Cazenave, 2010).

The characteristic of integrated coastal management (ICM) is dynamic, since the effect of climate change on coastal is enduringly growing. Cumulative effect of climate change on coastal is increasingly obvious. It is critical to redesign and adjust adaptation strategies in the future under climate change. In 1994, Chinese government published *China Ocean Agenda in 21st century*, which pointed out that ICM is an important way to guarantee marine sustainable development. Thereafter, related departments worked out rules and regulations to standardize management of coast. However, preparing for and coping with the impacts of climate change require the cooperation and coordination across regions and departments. In this case, the role that coastal management plays needs to be enforced. The management should pay attention to physical measures such as the improvement of public infrastructure in making adapting strategies (C.S. Organization,

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2007). Public participation is an indispensable part in integrated coastal management. Many countries have advocated that encouraging public participation is a key process in integrated coastal management. Efficient and effective participation is based on good social cognition (Lieske et al., 2014). Compared with other countries, China lacks efficient participants (Chen et al., 2017). Community with a great number of residents can be easily influenced by climate change, but few studies are conducted on the social cognition of climate change in coastal community (Elrick-Barr et al., 2015).

In middle of 1990s, Xiamen City was selected as a pilot site to demonstrate Integrated Coastal Management, which was mostly concerning land-based pollution control and marine environmental protection (Lin et al., 2007; Xue et al., 2004). In 1996, marine management office was founded by municipal government. A conducive platform was built for public participation. Public can provide their advices and ideas for costal management through telephone, email, questionnaire, hearing, letter visits and etc. These convenient ways improved ocean consciousness, environmental protection consciousness and low carbon awareness of residents, which also created a positive atmosphere for public participation. Xiamen City Xiamen City.

Our research will take Xiamen City as a case to explore the detailed social cognition at community level and their needs based on residents' understanding and preference. We believe that it is helpful to the development of adaptation strategies that reduce the adverse impact of climate change under ICM framework.

## 2. Method

In this study, we attempted to identify community-based measures to adapt climate change first. Thus, a questionnaire was designed to investigate residents' cognition of climate change and their selection preference of these adapting measures in the defined climate risk area. In the end, we used statistics methods to analyze the relationship between residents' characteristics, their cognition of climate change and its risk. In addition, we also wonder how residents' cognition influences their selection preference in Xiamen costal area (Fig. 1).

### 2.1. Study area

Xiamen is one of the five special economic zones of China established in 1980. It is situated on the southeast coast of Fujian Province in China and at the estuary of Jiulong River, which faces the Taiwan Island and the Penghu Island across the Taiwan Strait. The city covers total terrestrial area of 1573.16 km<sup>2</sup>, with the sea area of 390 km<sup>2</sup>. It is an important central city, a port city and a scenery touristy city in China's southeast coast. As a fast-developing coastal city, its GDP in 2015 is more than three times that of ten years ago. In industrial structure, the proportions of primary, secondary and tertiary industries were 0.7%, 43.5% and 55.8% in 2015 (Xiamen Statistics Bureau, 2015). During the past 40 years, it experiences an urban expansion from an island city to a bay city, which is driven by socio-economic factors together (Lin et al., 2010).

Xiamen has a subtropical maritime climate with abundant rainfall, whose average annual temperature is approximately 21 °C. However, with the climate change, Xiamen coastal zone is facing the risk of sea level rise and typhoon (Xu et al., 2016). According to the Bulletin of Climate published by Xiamen meteorological bureau in 2015, the climate features in Xiamen are significantly abnormal. Disastrous weather, such as rainstorm, typhoon and high temperature, occurs occasionally. There is a phenomenon we should pay close attention. 2014 is the hottest year on record, and the days whose temperature were above 35 °C reaches 43 days. There are 3.6 tropical cyclones that directly or indirectly affect Xiamen averagely per year. In 2016, typhoon Meranti, was one of the most intense tropical cyclones on record since 1949, which caused direct economic loss of RMB 10.2 billion in Xiamen City (Xiamen Statistics Bureau, 2016). Currently, sixteen percentage of the land elevation is lower than 10 m. Thus, the challenge caused by climate change in Xiamen is obvious.

### 2.2. Identification of community-based measures to adapt climate change

We identified three kinds of community-based measures to adapt climate change, protective measures, adjustment measures and evasion measures (Table 1). Protective measures can be divided into two sub-categories, hard measures and soft measures. Protective hard measures refer to use earthwork to make residential environment more secure. Protective soft measures focus on some ecological ways to enhance resilience of environment under climate change. Adjustment measures improve the anti-disaster capacity of costal residential district through optimizing its planning layout and infrastructure. These two types of measures are based on positive attitude to adapt climate change, while residents' positive attitude is determined by whether they take measures to strengthen their residence's resilience to climate change. If they have plans reactively to climate change, we think their attitudes are positive. Here, evasion measures such as maintaining the current state and evacuation are considered as negative attitude.

### 2.3. Risk areas of climate change

Risk areas of flooding caused by climate change in Xiamen were identified (Fig. 2). The prediction of inundated area is based on the situation of 1.2 m-sea-level rise and 100-year typhoon storm tide. First, we used ArcGIS 10.2 software to build a digital elevation model with a high-resolution digital topographic map (1:5000) and 10 × 10 m horizontal resolution. Second, we defined the prediction situation under the condition of 1.2-m-sea-level rise and 100-year typhoon storm tide. Third, we identified DEM cells as target cells when they lack seawalls or levees, or their elevation is lower than or equal to the water level adjacent to the sea. In the end, we overlaid a map of Xiamen with the target cells to rank the risk level. The overlap regions with the target cells we extracted are high-risk areas, and the others are low-risk areas.

There are 3.81 million permanent residents and 19.9% of them live in the high-risk area in Xiamen (Xiamen Statistics Bureau, 2015;

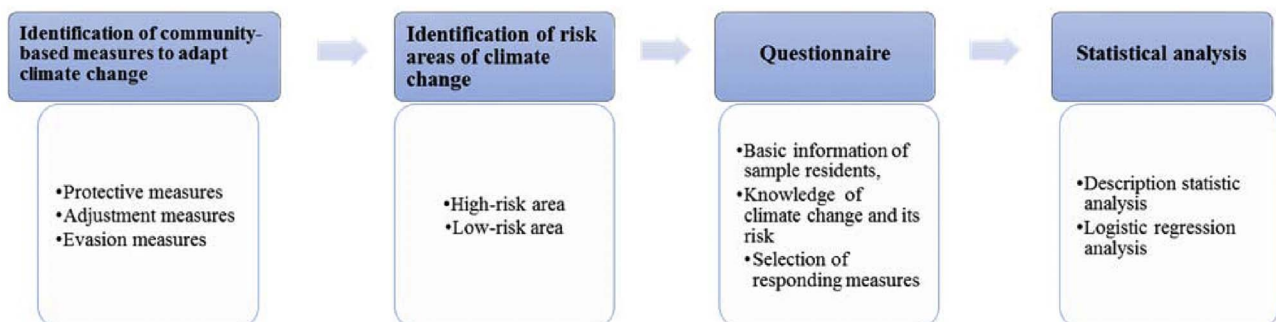


Fig. 1. Research method.

**Table 1**  
Summary of community-based measures to adapt climate change.

Type of Measures	Content of Measures	Corresponding Climate Change Event
Protective Measures	<b>Hard Measures (Earthwork)</b>	
	Building seawalls and revetment along coastline	Sea level rise
	Building levees along river bank	The flood caused by strong rainfall
	Building pile-foundation in coastal settlements to strengthen water nearby area	Typhoon storm surge
	Building protective engineering in geological hazard-prone Areas	The geological hazards caused by strong rainfall
		Typhoon storm surge and hurricane
	<b>Soft Measures (Ecological way)</b>	
	Designing residential ventilation ducts and green space system	Temperature rise
		Typhoon and hurricane
	Beach maintenance	Sea level rise
Adjustment Measures	Building buffer zone in wetland	The flood and sea level rise caused by strong rainfall
	Building costal windbreak forest	Typhoon storm surge
	Building landscape engineering for soil and water conservation	The geological hazards caused by strong rainfall
		Typhoon storm tide and hurricane
	Residential district space and construction control	All climate change events
	Optimizing building layout and improving monomer building design in residential district	Temperature rise and typhoon storm tide
		The flood and typhoon storm surge caused by strong rainfall and sea level rise
	Optimizing transportation and municipal infrastructure in residential district	Flood and typhoon storm tide caused by temperature rise
		Strong rainfall and sea level rise
	Strengthening disaster prevention and reduction facilities building in residential district	All meteorological disasters
Evasion Measures	Improving ecological performance of outdoor space and vertical design standard of building in residential district	The flood and sea Level rise caused by strong rainfall
		Temperature rise
		Extreme climatic event including typhoon storm tide and hurricane, etc.
	Improving the safeguarding for preventing the flood of water flowing into underground space in residential district	Backflow of seawater caused by sea level rise
	Building emergency safe drinking water support system in residence district	Flood
	Maintaining current state Evacuation	Secondary disaster

Wikipedia, 2016). Moreover, the residential area in high-risk area account for about one-third of the city.

#### 2.4. Questionnaire design and survey

The questionnaire (see [appendix A](#)) contains three aspects: basic information of sample residents, knowledge of climate change and its risk, and selection of responding measures ([Table 2](#)). The knowledge of the climate change includes the contents, impacts and consequences of climate change, which was present on questionnaire through totally 15 detailed options in the three questions (question no. 1 to no.3). We divided residents' cognition level of climate change in four levels by the number of selected option. Selected options are greater than or equal to 12 for high cognition, 9–12 for relatively high cognition, 6–9 for relatively low cognition and lower than 6 for low cognition. In addition, we evaluated resident's risk cognition by whether they can assess correct risk level of their community. Furthermore, attitude towards consequences of climate change was investigated. There are three options respectively taking positive measures, maintaining current state and evacuation. In the end of the questionnaire, we investigated the preference for protective measures and adjustment measures.

Face-to-face questionnaire survey was conducted by using stratified sampling method in October 2014. We also explained the questions to respondents so as to make sure that they really understood each question. We surveyed a random sampling in 29 selected coastal communities in Xiamen, which consisted of 14 communities in high risk area and 15 communities in low risk area. We sent out 602 questionnaires, of which 595 were valid.

#### 2.5. Statistical analysis

We used logistic regression to analyze the impact of residents' socioeconomic characteristics on their cognition of climate change and its risk. During the first step of the analysis, we used Spearman coefficient

to assess whether there exists correlation in explanatory variable. Before model building, Chi-squared test was used to select proper factors for logistic regression model. We considered that different personal background will make influence on their choice. Hence, we took individual values as a parameter when conducting Chi-squared test. Moreover, we also tested whether the cognition of climate change and its risk has an effect on the selection preference of adapting measures ([Fig. 3](#)).

Logistic regression is a statistical model based on a transformation of a linear equation. The probability of dependent variable can be mathematically expressed as a function of several explanatory variables using a binomial logistic distribution. This model could screen factors that significantly influence the dependent variable in quantity by the regression coefficients and the odds ratio (OR), which are helpful to identify main effect factors. In addition, logistic regression is extended to handle outcome variables that have more than two categories. Polytomous logistic regression is used when the categories of the dependent variable are nominal and more than two categories. When the categories of the dependent variable do have a natural order, ordinal logistic regression may also be appropriate ([Technometrics, 2010](#)). Under this model, the estimated parameter is invariant no matter where the outcome categories are dichotomized. The goodness-of-fit of the model to the data can be evaluated by likelihood-ratio test and Hosmer-Lemeshow test. The predictive power of the model can be test by the ROC curve drawn by the prediction probability.

### 3. Results and discussion

#### 3.1. The state of costal residents' cognition of climate change

According to the four grades of cognition of climate change in Xiamen costal community, 58.2% of costal residents' cognition level is low and relatively low. There are totally 15 effects in the second part of the questionnaire and average number of selected effects are about 7.9, namely staying in the level of relatively low ([Fig. 4](#)).

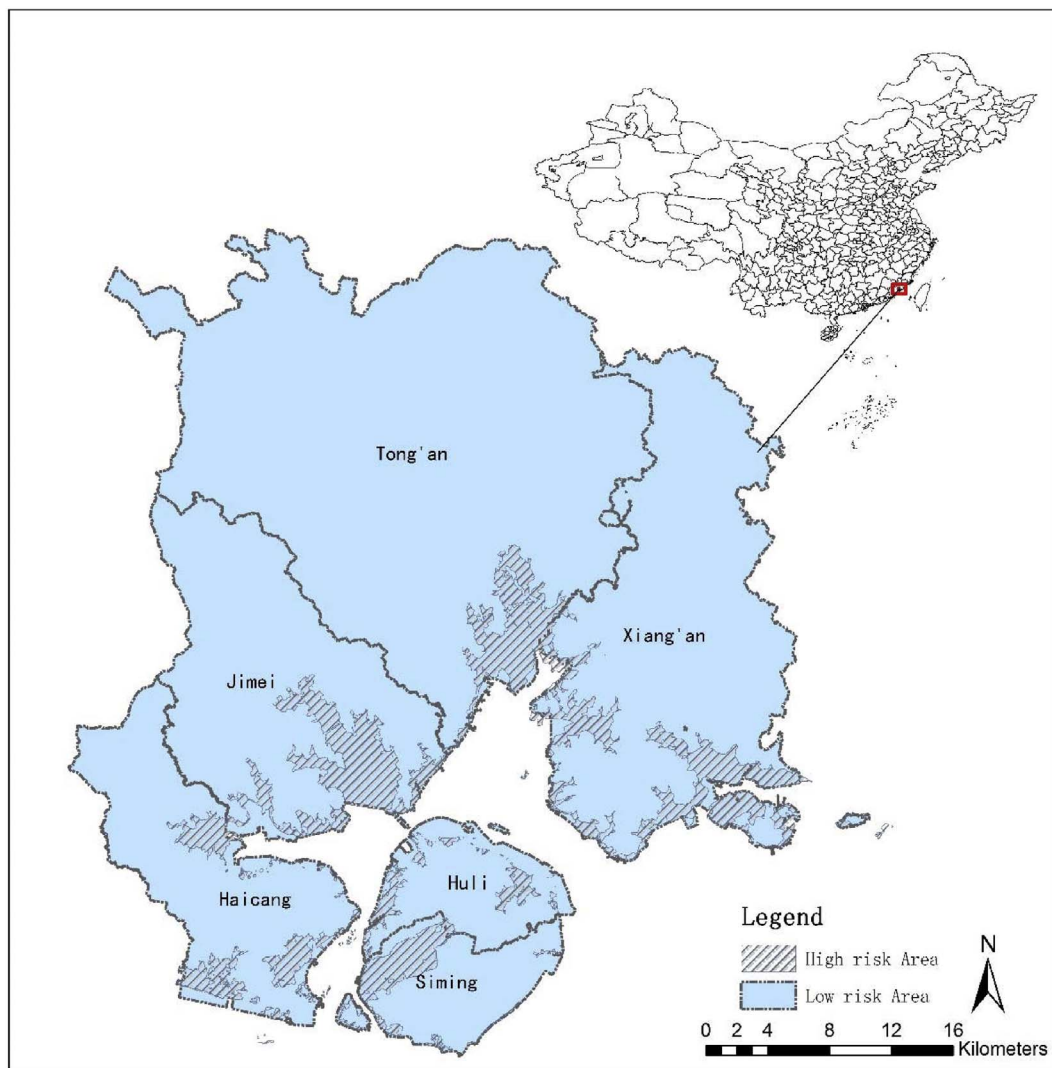


Fig. 2. Risk areas of climate change in Xiamen City.

**Table 2**  
Questionnaire content.

Survey Items	Questionnaire Content
Basic information of residents	Type of residence
	Number of family member
	Gender
	Age
	Level of education
Cognition of the climate change and its risk	Household income
	Contents of climate change
	Impacts of climate change
	Consequences of climate change
	Residents' self-assessment of risk of climate change
Selection of responding measures	Attitude towards risk of climate change
	Preference of measures adapting climate change
	change of measures adapting climate change

As for the details of residents' preferences (Table 3), temperature rise can be easily identified by people, while sea level rise is less known by residents. The ratios of urban heat island effect and biodiversity loss is in the lead as for the impact of climate change. These two types occurred 62.5% and 61.5% respectively. Of 5 consequences of climate change, 507 respondents (85.2% of all respondents) indicated that

climate change could threaten human health. Concerns about damage of municipal infrastructure and transportation rank second.

We calculated the correlation coefficients of the explanatory variables before applying logistic regression. The explanatory variables in all models include the following: household registration, gender, family number, age, education level, household income, risk level of residence and self-assessment of residence risk level. These spearman coefficients are on the interval from 0.001 to 0.586, which are less than the threshold of 0.8 (Technometrics, 2010). Due to the natural ordering among the cognition levels of climate change, all explanatory variables can be involved into ordinary logistic model. We filtered factors whose  $p$ -value is less than 0.25 through Chi-squared test as follow: household registration ( $p = 0.031$ ), age ( $p = 0.163$ ), education level ( $p = 0.001$ ), household income ( $p = 0.081$ ), and self-assessment of residence risk level ( $p = 0.001$ ) before model building. We found significant positive relationships between residents' cognition of climate change and education level, household income, and self-assessment of residence risk level (Table 4).

This model suggests that residents with higher education level are more likely to have higher climate change cognition. There is no significant difference between groups who have bachelor's degree and master's degree. It could be that the public acquire most knowledge on climate change in university and form a stable opinion at this stage.

Residents' cognition level improves when their household income is less than 20000 RMB per month. Most residents whose household

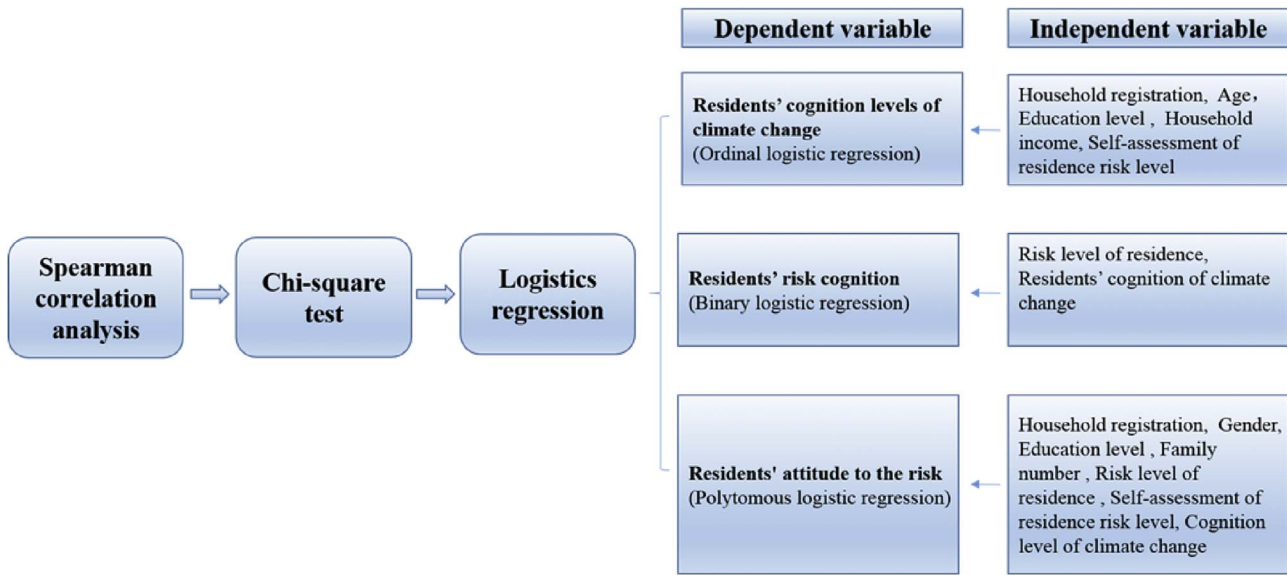


Fig. 3. Logistic regression model building.

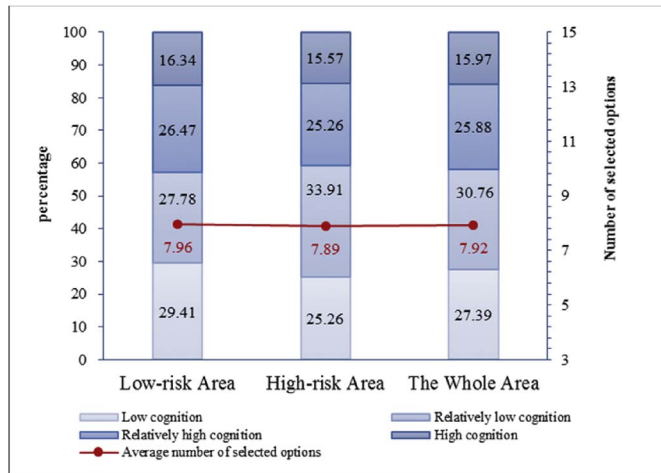


Fig. 4. Coastal residents' cognition level in Xiamen City.

**Table 3**  
Coastal residents' selected options of climate change.

Items	Effects	Frequency	Percentage (%)
Contents of Climate Change	<b>Temperature rise</b>	<b>477</b>	<b>80.2</b>
	Sea level rise	202	34.0
	Precipitation change	325	54.6
	Extreme climate events	274	46.1
Impacts of Climate Change	<b>Urban heat island effect</b>	<b>372</b>	<b>62.5</b>
	Increased aridity	342	57.5
	<b>Biodiversity loss</b>	<b>366</b>	<b>61.5</b>
	Backflow of seawater	210	35.3
	Increased flooding	276	46.4
	Increased geological hazard	313	52.6
Consequences of Climate Change	<b>Threat for human health</b>	<b>507</b>	<b>85.2</b>
	Property damage	269	45.2
	Shortage of food supply	322	54.1
	<b>Municipal infrastructure and transportation damage</b>	<b>378</b>	<b>63.5</b>
	Blocking economic growth	79	13.3

Bold signifies the one or two of the highest frequency in each items.

income is more than 20,000 RMB per month stay at low and relatively low cognition level, which is no significant different from the group of less than 2000 RMB per month. This result is surprise and the underlying reason is unclear. The residents may reduce their attentive extent to climate change when they believe their income is high enough to cope with consequences caused by climate change.

If residents think their residence belongs to none-risk area, the probability of respondents who have a higher cognition level is much less than (0.205 times of) the residents who think they live in high-risk area. In other words, residents' cognition is higher when the risk level of residence they defined by themselves rise. Although most respondents believe residences they live have risk, their cognition level of climate change is similar. This shows residents' perception of risk is not clear in Xiamen coastal communities.

### 3.2. Coastal residents' risk cognition in Xiamen City

We defined risk cognition as whether residents could assess the right residence risk level they live. 338 residents (56.8% of respondents) think they live in low-risk area while 4.7% of them think the risk level of their residence belong to high-risk area. However, about half of responses (289 residents) live in high-risk area actually. Only 14 respondents have right risk cognition among them. Moreover, 53.3% of them believe that they live in low-risk area even 15 think they reside in none-risk area. As for respondents lived in low-risk area, 60.1% of them have right risk cognition (Fig. 5).

We analyzed whether residents' personal attributes influence their risk perceptions. The result shows that personal attributes do not significantly affect risk perception. Then, we did further study on the relationship among residents' cognition of climate change, risk level of residence and their risk perception. We took risk level of residence ( $p < 0.001$ ) and residents' cognition of climate change ( $p < 0.001$ ) into binary logistic model. We found a significant positive relationship between residents' risk cognition and risk level of residence (Table 5). Residents living in low-risk area have more accurate risk cognition. However, the cognition of climate change does not have significant difference between the group who live in low-risk areas and high-risk areas. This could be that most residents generally are too optimistic and believe they live in low-risk area no matter what kind of risk level of their residence. Perhaps, no efficient and enough propagation and education on risk caused by climate change is one of important reason. Our results also show that higher cognition of climate change will lead

**Table 4**  
Ordinal logistic regression coefficients of the factors affecting residents' cognition of climate change.

Variables	Sub-variables	B	S.E.	Wald	df	P-value	OR (95% C.I.)
Threshold	Low cognition	−2.931	0.816	12.895	1	0.000	0.050(0.011–0.264)
	Relatively low cognition	−1.353	0.811	2.785	1	0.095	0.259(0.053–1.266)
	Relatively high cognition	0.176	0.808	0.047	1	0.828	1.192(0.245–5.810)
Household Registration	Local residents	0.067	0.163	0.166	1	0.684	1.069(0.776–1.472)
	Foreign residents	0	.	.	0	.	.
Age	≤ 24	−0.386	0.432	0.799	1	0.372	0.680(0.292–1.585)
	25–30	−0.426	0.421	1.025	1	0.311	0.653(0.286–1.490)
	31–40	−0.283	0.418	0.460	1	0.498	0.753(0.332–1.708)
	41–50	−0.388	0.440	0.777	1	0.378	0.678(0.286–1.607)
	51–60	−0.702	0.572	1.507	1	0.220	0.495(0.161–1.521)
	> 60	0	.	.	0	.	.
Education level	Primary school	−3.496	0.732	22.786	1	<b>0.000***</b>	0.030(0.007–0.127)
	Junior high school	−3.105	0.613	25.637	1	<b>0.000***</b>	0.045(0.013–0.149)
	Senior high school/technical secondary school	−2.023	0.579	12.206	1	<b>0.000***</b>	0.132 ( 0.042–0.411 )
	Bachelor	−0.925	0.566	2.672	1	0.102	0.396(0.131–1.202)
	Master	0	.	.	0	.	.
Household income	≤ 2000 RMB	0.687	0.441	2.430	1	0.119	1.989(0.838–4.720)
	2000–5000 RMB	0.543	0.304	3.186	1	<b>0.074*</b>	1.721(0.948–3.126)
	5000–10000 RMB	0.508	0.301	2.857	1	<b>0.091*</b>	1.663(0.922–2.999)
	10000–20000RMB	0.663	0.319	4.311	1	<b>0.038**</b>	1.940(1.038–3.627)
	> 20000RMB	0	.	.	0	.	.
Risk level of residence	Low-risk area (real)	0.221	0.156	2.015	1	0.156	1.248(0.919–1.694)
	High-risk area(real)	0	.	.	0	.	.
Self-assessment of residence risk level	None-risk area	−1.586	0.483	10.778	1	<b>0.001***</b>	0.205(0.079–0.528)
	Low-risk area	−0.319	0.366	0.762	1	0.383	0.727(0.355–1.489)
	Moderate-risk area	−0.010	0.377	0.001	1	0.979	0.990(0.473–2.071)
	High-risk area	0	.	.	0	.	.

Bold signifies that the p-value of the factor is significant.

\*\*\*, \*\* and \*, Significant at  $P < 0.01$ ,  $P < 0.05$ , and  $P < 0.10$ , respectively. B, Parameter estimate; SE, Standard error. -2log likelihood is 1129.426, Chi square statistic is 148.618\*\*\*; Chi square statistic in test of parallel lines is 28.337\*\*\*; the area under the ROC curve is 0.732\*\*\*.

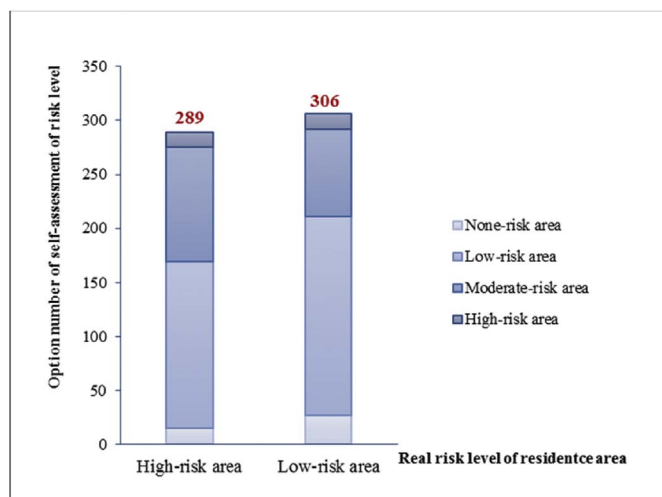


Fig. 5. Coastal residents' risk cognition in Xiamen City.

to correct risk cognition. The probability of correct risk cognition occurs 1.35–1.68 times with cognition level of climate change rise. That is to say, improving residents' cognition of climate change is helpful to enhance their risk cognition.

### 3.3. Coastal residents' attitude to the risk resulted from climate change

Most of coastal residents (414 out of 595, 69.6%) will adopt positively respond measures to adapt the climate change. Thus, the research of community-based planning and management to respond the climate change is urgently in need in Chinese coastal area (Table 6).

Through Chi-squared test, seven explanatory factors as following were selected into polytomous logistic regression model (Table 7): household registration ( $p = 0.096$ ), gender ( $p = 0.114$ ), education level ( $p = 0.118$ ), family number ( $p = 0.036$ ), risk level of residence ( $p = 0.042$ ), self-assessment of residence risk level ( $p = 0.018$ ), and cognition level of climate change ( $p = 0.20$ ).

Compared with foreign residents, local residents tend to maintain current state rather than evacuation, who choose to maintain current state is 2.08 times than foreign residents. That is to say, the foreign population prefer to leave when climate disaster occurs, meanwhile

**Table 5**  
Binary logistic regression coefficients of the factors affecting residents' risk cognition of climate change.

Variables	Sub-variables	B	S.E.	Walds	df	P-value	OR (95% C.I.)
Risk level of residence	-	−3.450	0.301	131.074	1	<b>0.000***</b>	0.032(0.018–0.057)
	Cognition level	−	−	6.813	3	<b>0.078*</b>	−
	Relatively low cognition	0.519	0.287	3.278	1	<b>0.070*</b>	1.680(0.958–2.947)
	Relatively high cognition	0.737	0.295	6.237	1	<b>0.013**</b>	2.090(1.172–3.728)
Constant	High cognition	0.300	0.335	0.804	1	0.370	1.350(0.700–2.602)
	-	3.481	0.385	81.615	1	0	32.478

Bold signifies that the p-value of the factor is significant.

\*\*\*, \*\* and \*, Significant at  $P < 0.01$ ,  $P < 0.05$ , and  $P < 0.10$ , respectively. B, Parameter estimate; SE, Standard error. -2log likelihood is 516.700, Chi square statistic is 240.289\*\*\*; the area under the ROC curve is 0.732\*\*\*.

**Table 6**  
Coastal residents' selected attitude to the risk caused by climate change.

Measures	Frequency	Proportion (%)
Maintaining current state	74	12.4
Evacuation	107	18.0
Taking positive measures to adapt	<b>414</b>	<b>69.6</b>
Total	595	100

Bold signifies the one or two of the highest frequency in each items.

local residents are more likely to make change in their daily life to adapt to climate change.

This model also shows that residents with high-cognition tend to evacuation than maintain current state. When residents' cognition turns to high level from low level, the probability of evacuation is 5.1 times than ever, which means the possibility of residents that want to leave coastal city will increase if they have deep insight into climate change. In Section 3.2, we proved that residents with high-cognition of climate change have more accurate risk-cognition. In this perspective, we can understand the preference of evacuation. If residences lack disaster

prevention measures, those residents will tend to leave. Therefore, it is necessary to enhance disaster prevention and mitigation capacity and boost residents' confidence in adapting climate change.

Moreover, residents who consider they live in high risk area prefer to maintain current state than evacuation. Even they feel that their residence belongs to high grade risk level, they prefer to positively respond to climate change. Furthermore, residents who prefer to take positive measures are female, the part with junior high school diploma and live in low-risk area. In past studies, the vulnerable groups of climate change includes women and low-education population (Alston, 2014). These may make them assume that the risk of climate change is under control. It is necessary to strengthen propaganda and education of the knowledge in community and schools about climate change and its risk among residents, especially for the vulnerable groups such as female and children.

### 3.4. Coastal residents' preference of measures to the risk caused by climate change

Among the nine specific positive measures, the proportion of protective hard measures and protective soft measures selected is 20.2% and 21.9% respectively, which means residents are more likely to

**Table 7**  
Polytomous logistic regression coefficients of the factors affecting residents' attitude to the risk caused by climate change.

Attitude	Variables	B	S.E.	Wald	df	P-value	OR (95% C.I.)
Maintaining current state	Constant	0.676	1.458	0.215	1	0.643	
	Family number	0.056	0.133	0.179	1	0.672	1.058 (0.815–1.319)
	Household Registration	0.734	0.326	5.081	1	<b>0.024**</b>	2.083 (1.101–3.944)
		0	.	.	0	.	.
	Gender	–0.337	0.320	1.113	1	0.291	0.714 (0.381–1.336)
		0	.	.	0	.	.
	Education level	0.231	1.182	0.038	1	0.845	1.260(0.124–12.777)
		1.020	1.064	0.918	1	0.338	2.772(0.344–22.303)
		0.241	0.982	0.060	1	0.806	1.272 (0.186–8.709)
		0.645	0.951	0.460	1	0.498	1.906(0.296–12.283)
		0	.	.	0	.	.
	Risk level of residence	0.011	0.321	0.001	1	0.972	1.011(0.539–1.898)
		0	.	.	0	.	.
	Self-assessment of residence risk level	–2.786	1.214	5.263	1	<b>0.022**</b>	0.062(0.006–0.666)
		–2.954	1.101	7.193	1	<b>0.007**</b>	0.052 (0.006–0.451)
		–2.506	1.108	5.117	1	<b>0.024**</b>	0.082 (0.009–0.716)
		0	.	.	0	.	.
	Cognition level	1.630	0.565	8.326	1	<b>0.004**</b>	5.104(1.687–15.443)
		0.591	0.516	1.313	1	0.252	1.806 ( 0.657–4.964 )
		0.022	0.541	0.002	1	0.968	1.022 ( 0.354–2.948 )
		0	.	.	0	.	.
Taking positive measures to adapting	Constant	1.607	1.247	1.661	1	0.198	
	Family number	–0.003	0.094	0.001	1	0.973	0.997 (0.829–1.199)
	Household registration	0.111	0.228	0.238	1	0.625	1.118 (0.715–1.749)
		0	.	.	0	.	.
	Gender	–0.423	0.228	3.450	1	<b>0.063*</b>	0.655(0.419–1.024)
		0	.	.	0	.	.
	Education level	0.874	0.893	0.958	1	0.328	2.396(0.416–13.791)
		1.841	0.795	5.358	1	<b>0.021**</b>	6.301(1.326–29.943)
		1.162	0.715	2.642	1	0.104	3.195(0.787–12.969)
		1.259	0.697	3.268	1	<b>0.071*</b>	3.524(0.899–13.803)
		0	.	.	0	.	.
	Risk level of residence	0.421	0.227	3.444	1	<b>0.063*</b>	1.523 (0.977–2.375)
		0	.	.	0	.	.
	Self-assessment of residence risk level	–2.158	1.121	3.701	1	<b>0.054*</b>	0.116(0.013–1.041)
		–1.723	1.045	2.719	1	<b>0.099*</b>	0.178(0.023–1.384)
		–1.884	1.052	3.208	1	<b>0.073*</b>	0.152(0.019–1.194)
		0	.	.	0	.	.
	Cognition level	0.568	0.399	2.029	1	0.154	1.765 (0.808–3.859)
		0.258	0.336	0.590	1	0.442	1.294 (0.670–2.498)
		0.137	0.333	0.170	1	0.680	1.147(0.597–2.204)
		0	.	.	0	.	.

Bold signifies that the p-value of the factor is significant.

\*\*\*, \*\* and \*, Significant at  $P < 0.01$ ,  $P < 0.05$ , and  $P < 0.10$ , respectively. B, Parameter estimate; SE, Standard error. -2log likelihood is 783.001, Chi square statistic is 56.682\*\*\*, the area under the ROC curve is 0.628\*\*\*.

**Table 8**  
Costal residents' selected preference of measures to the risk caused by climate change in Xiamen.

Type of measures	Subtype of measures	Frequency	Proportion (%)
Protective measures	Hard measures	<b>360</b>	<b>20.2</b>
	Soft measures	<b>390</b>	<b>21.9</b>
Adjustment measures	Residential district space and construction control	78	4.4
	Optimizing building layout and improving monomer building design in residential district	141	7.9
	Optimizing transportation and municipal infrastructure in residential district	<b>244</b>	<b>13.7</b>
	Strengthening disaster prevention and reduction facilities building in residential district	<b>208</b>	<b>11.7</b>
	Improving ecological performance of outdoor space and vertical design standard of building in residential district	129	7.2
	Improving the safeguarding for preventing the flood of water flowing into underground space in residential district	42	2.4
	Building emergency safe drinking water support system in residence district	<b>193</b>	<b>10.8</b>

Bold signifies the one or two of the highest frequency in each items.

**Table 9**  
Costal residents' preference of type of measures to the risk caused by climate change in Xiamen.

Type of measures	Frequency	Proportion (%)
Protective measures& adjustment measures	227	38.2
Protective hard measures& adjustment measures	133	22.4
Protective soft measures& adjustment measures	163	27.4
Adjustment measures	72	12.1
Total	595	100.0

choose protective measures. As for adjustment measures, measures that play direct roles in residents' daily life are more popular, such as optimizing transportation and municipal infrastructure in residential district, strengthening disaster prevention and reduction facilities building in residential district, and building emergency safe drinking water support system in residence district (Table 8). The preference may also be affected by the cost of measures. In fact, although the cost of protective measures such as building seawares and levees is high, it is still lower compared to the adjustment measures. In addition, this kind of measures is easier to implement in built area in city. Hence, the cost of construction and maintenance is crucial element that should be taken into consideration in decision-making. With the development of urban construction, attaching increasing importance to adapt climate change in planning can nip in the bud. Residents prefer to select more than two categories of measures to adapt climate change (Table 9). There is no significant factor affecting residents' selection preference of combination of measures in chi-square test. Obviously, a single measure has some limitations, combining multiple measures will optimize the effect of adapting climate change.

#### 4. Conclusion

We found that Xiamen residents' knowledge on climate change is still at relatively low level although the challenge of climate change is serious, which is affected by the following factors in order: education level (+), self-assessment of residence risk level (+) and household income (+). Although most of residents are aware of the risk of climate change, few of them know their real risk level. The factors that have influences on risk cognition refer to risk level of residence (−) and cognition level of climate change (+). Most residents prefer positive measures to adapt climate change. The affecting factors are as following in sequence: self-assessment of residence risk level (+), education level (−), cognition level (−), household registration (−), gender (+), risk level of residence (−).

Among various measures for adapting climate change, residents are more likely to choose protective measures. The reason could be that the cost of the protective measures is relatively lower than the adjustment measures. The hard and soft measures have nearly the same proportion. As for several adjustment measures, residents tend to prefer the measures with direct effect on adapting climate change than those with

indirect effect. Residents prefer to select more than two categories of measures to adapting climate change. There is no significant factor affecting residents' selection preference of combination of measures.

Public participation is important for integrated coastal zone management under climate change. It is necessary to develop the collaborative mechanism of management system and enhance cooperation between government and the public in order to guarantee the development of responding measures to climate change. Community based planning and management to respond the climate change is urgently needed in the rapid urbanization coastal area in China. Further studies need to address how to improve the public's cognition of climate change and its risk, as well as to build coastal residents' confidence on adapting climate change with highly flexible and practical measures.

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#### Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.ocecoaman.2018.02.025>.

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